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WITH ABSTRACT OF THE LITERATURE

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A Study of Dysmenorrhea at the Home Office of the Metropolitan Life Insurance Company

Observations on the Working Capacity of Coal Miners in Relation to Atmospheric Conditions

A New Instrument for Measuring Cooling Power: The Coolometer

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THE JOURNAL OF INDUSTRIAL HYGIENE

VOLUME XIII SEPTEMBER, 1931 NUMBER 7

BUTCHERS' DERMATITIS*

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INTRODUCTION

BUTCHERS' dermatitis, commonly known as "swine itch" and also known as "cattle itch" and "sheep itch," is an occupational disease largely confined to butchers working in meat packing establishments but also affecting other persons who handle freshly killed carcasses of hogs, cattle, and sheep. Veterinarians and others engaged in meat inspection work are also affected with this dermatitis, which, while seldom if ever producing serious effects, is responsible for considerable irritation and discomfort, and results sometimes in loss of time from work on account of the intense irritation and itching which develop on the hands and other parts of the body of susceptible persons. Inspectors of the Bureau of Animal Industry have been affected with this dermatitis to an extent which has made it necessary to change their assignments from time to time in order to afford them relief from a condition which tends to become increasingly aggravated as a result of continuous exposure, incident to the inspection of carcasses, and particularly the viscera, of various classes of meat food animals.

Although this dermatitis is well known to butchers and other packing house employees, and to veterinarians and others engaged in meat inspection work, and although it is accurately diagnosed by some physicians employed in meat packing establishments, it does not appear to be well known to the medical profession generally and accounts of it do not appear to have been included in treatises on dermatology and on occupational diseases.

HISTORY OF PRESENT INVESTIGATION

The writer's attention was directed to this dermatitis by Dr. A. J. Pistor of the administrative staff of the Meat

* Received for publication May 13, 1931.

Inspection Division of the Bureau of Animal Iudustry, who suggested the desirability of determining whether this skin affection had any relation to, or was perhaps identical with, Ascaris sensitization, or whether it represented a sensitization to some other common parasite of meat food animals. Following the publication of a statement in the Service and Regulatory Announcements of the Bureau of Animal Industry[1] concerning so-called swine itch, in which government inspectors were requested to submit data concerning this skin affection, replies were received from inspectors of twenty-three meat packing establishments operating under government supervision.[2] While a number of replies merely contained data based on the personal experience of the correspondent, other communications contained data covering a number of cases and, in several instances, numerous cases which had occurred among inspectors, butchers, and others working in abattoirs. In a number of instances clear-cut and concise histories were furnished by veterinary inspectors who had had, or were still suffering from, this dermatitis.

Although the facts presented in the following pages are based, for the most part, on information submitted by these correspondents, the data have been supplied in all cases by professional men trained in veterinary medicine, thoroughly familiar with gross pathology, and with daily experience in making accurate observations on and diagnoses of various pathologic conditions of cattle, sheep, and swine. This information regarding the appearance, symptoms, lesions, predisposing causes, and other factors entering into the picture of this dermatitis is in close agreement, and is fully confirmed by the testimony of laboratory workers and administrative officials of the Bureau of Animal Industry in Washington, D. C., who had suffered from this skin affection while engaged in meat inspection work. The available evidence points to a rather widespread skin disease in butchers and others who handle freshly killed carcasses of meat food animals. This skin affection appears to be related to that recently described by Taylor[3] as resulting from the dressing of freshly killed rabbits.

Symptoms and Lesions

The lesions of butchers' dermatitis are erythematous areas on the affected parts, accompanied by the formation of pinhead vesicles and followed by eruptions, with intense itching as a symptom. The reddening, which at times is accompanied by a moderate or marked swelling, is first observed in the webs between the fingers; this is accompanied by itching. One or two days after these symptoms are noticed, pinhead vesicles appear, and one or two days after their appearance the vesicles erupt, liberating a clear serous fluid; this produces intense

[1] March, 1929.

[2] The data were submitted from the following localities: Phoenix, Ariz.; Sacramento, Calif.; Denver, Colo.; Sandpoint, Idaho; Chicago and East St. Louis, Ill.; Frankfort and Indianapolis, Ind.; Cedar Rapids, Davenport, and Ottumwa, Iowa; Arkansas City and Kansas City, Kan.; Baltimore, Md.; South St. Paul, Minn.; New York, N. Y.; Pittstown, Pa.; Fort Worth, Texas; Ogden, Utah.

[3] Taylor, F. R.: Epidemic of Dermatitis Venenata Due to a Hitherto Undescribed Cause. Jour. Am. Med. Assn., 1930, *94*, 1916.

itching. The lesions spread to the sides and backs of the fingers, and over the back of the hand as far as the wrist; in some cases this dermatitis spreads to the arm, reaching as far as the elbow. Following the eruption of the vesicles, the affected skin hardens and forms scabs or crusts which peel off, exposing the newly formed, tender skin which in turn hardens and cracks. This process may be repeated a number of times, if the condition is not treated. In severe cases the vesicles become confluent, resulting in considerable desquamation following eruption. The formation of vesicles is an almost constant manifestation of this condition. While several reports fail to mention the appearance of vesicles, only one report contains a positive statement that vesicles did not develop. The latter case was very mild, and the lesions were limited to the interdigital skin.

Owing to the fact that this dermatitis is well known to butchers and others working in packing houses, persons exposed to it by virtue of their occupational assignments are frequently given warning and advice by their fellow workers regarding treatment, and are particularly urged to use local applications, which commonly arrest the progress of the dermatitis. This may account, at least in part, for the variations in the severity of symptoms and also for the variations in duration of this skin disease. Some reports contain statements that the areas involved were only those between the fingers, and that the condition lasted for a relatively short time; whereas other reports state that the lesions spread to the backs of the hands and arms up to the elbows, and that in certain cases lesions have been found also on other parts of the body, including the chest, abdomen, legs, forehead, face and eyelids, with repeated attacks. The occurrence of symptoms and lesions on parts of the body other than the hands and arms is, however, exceptional.

Cause

While the exact cause of this dermatitis is still a matter of speculation, the affection is not due to a sensitization to Ascaris or to any other parasite of livestock; it is traceable in nearly all cases to close contact with, and more particularly constant handling of, various parts of the carcasses, and especially the viscera, of freshly killed meat food animals. The dermatitis is more frequently associated with the handling of freshly killed swine carcasses than with the handling of carcasses of other meat food animals; hence the vernacular name swine itch, by which this skin affection is commonly known in meat packing establishments. The available data indicate, however, that the handling of cattle carcasses is also a very common cause of this dermatitis, in which case its vernacular name is cattle itch. In a relatively small number of cases, this skin affection is reported to result from the handling of sheep carcasses, and in such cases it is commonly referred to as sheep itch.

The data submitted by the inspectors from twenty-three meat packing establishments show that in all these establishments butchers' dermatitis has occurred in susceptible persons as a result of handling swine carcasses. In seventeen of these establishments it has also developed in various persons as a result of handling cattle carcasses.

In the report submitted from one establishment it is stated that butchers' dermatitis does not occur in connection with the handling of cattle carcasses, and in another establishment it has not been observed in connection with the handling of these carcasses. In the reports submitted by inspectors from four different establishments, no reference is made to this dermatitis in connection with work on cattle carcasses. In reports involving six establishments, the dermatitis was traced to the handling of sheep carcasses; reports from fifteen establishments make no reference to sheep carcasses; and two reports state that the dermatitis has not been known to develop in connection with the handling of sheep carcasses.

As far as individual susceptibility to various classes of meat food animals is concerned, the case histories submitted by meat inspectors show that some persons are equally susceptible to cattle, sheep, and swine carcasses; nearly all inspectors who have developed this dermatitis as a result of handling swine carcasses have also developed it as a result of handling cattle carcasses. One case history shows, however, that the person concerned failed to develop the dermatitis as a result of exposure to swine carcasses, but developed it readily while handling sheep and cattle carcasses; another person was unaffected by swine carcasses but susceptible to cattle carcasses; of two inspectors who were affected by swine carcasses, one was unaffected by cattle and sheep carcasses, and one stated that he was unaffected by cattle carcasses but made no reference to sheep carcasses.

Though this skin trouble affects particularly those who handle viscera, butchers and others who do not come in contact with the viscera are also affected, if susceptible. Among hog butchers, the eviscerators, leaf lard pullers, splitters, and gut pullers are especially likely to develop this dermatitis; those engaged in shaving the skin, in head dropping, and in head cleaning are also frequently affected. Workers in the stockyards and those engaged in cutting up the carcasses in the cutting rooms are said not to be affected. In some cases, scalders also develop the skin affection, while in other cases they are reported to escape it.

Among cattle butchers, the leg breakers, floormen, siders, head droppers, gutters, and paunch workers are the ones most frequently affected. Among inspectors, those who inspect the viscera are more frequently affected than those who inspect the heads. It is of interest to note that one inspector who was extremely susceptible to the handling of swine carcasses reports that when he was engaged in tuberculin testing of cattle in the field, and was not in contact with swine, he developed this dermatitis as a result of contact with the cattle to which he applied the test. Another veterinarian who had been troubled with this dermatitis in abattoirs, while engaged in meat inspection, stated that he was equally susceptible to contact with horses, and developed a similar skin affection as a result of performing surgical operations on horses and as a result of getting horse saliva on his hands while filing horses' teeth. An illustration of an extreme and somewhat selective susceptibility is the case of a butcher who is reported as being extremely susceptible while

engaged in paunch trimming, but unaffected while engaged in skinning or head cleaning in connection with the slaughtering of cattle. One case, which came to the writer's personal attention and which is of several years' standing, is that of a sausage maker who does not handle fresh casings; this man inspects salted hog, beef and sheep casings which are shipped from a distant point, handles pork while in the process of curing, and also handles raw and rendered lard. Examination of the hands revealed pin point vesicles, and considerable cracking of the skin on the fingers and on the backs of the hands. Reports of other cases occurring among packing house employees who do not handle fresh carcasses were brought to the writer's attention.

Onset and Duration

This dermatitis does not appear immediately after exposure, but usually requires a period of sensitization of varying duration. Three days following the initial exposure appears to be the shortest period before the symptoms appear in the inspectors who have developed the skin trouble for the first time. One man stated that he had worked for thirty days before he discovered that he had contracted swine itch; in one person it appeared in less than two weeks after he had entered on his duties as an inspector; other correspondents submitted information to the effect that the period of sensitization varied from four to ten days.

The duration of butchers' dermatitis varies in different persons, presumably depending on the degree of their susceptibility, on their use of preventive and remedial measures, and also on the development of resistance. Certain persons report only one attack of relatively short duration. Thus, one inspector states that he had one attack which lasted only two days and that there has been no recurrence; another states that his attack lasted only a few days and that he was relieved following treatment; one report states that the dermatitis lasted a week and was held in check by preventive measures, despite continued exposure. Certain persons report that the affection lasts several weeks, others state that it lasts several months, while some inspectors state that they suffered from it for years. One history shows that the person concerned was never free from this dermatitis during several years of meat inspection work, during which time he resorted to no treatment; another shows that the subject suffered from it from 1912 to 1915; one inspector reports that he suffered from it for three years; and another states that he had it many times during the first four or five years of his work as an inspector.

On the basis of available data, it is evident that butchers' dermatitis does not appear immediately following exposure in susceptible persons; a period of sensitization, of varying duration, seems to be involved in the cases available to the writer. The duration of the dermatitis is irregular, and varies with individual susceptibility and with the degree of care which different persons exercise either to prevent its recurrence or to keep it in check, once it has made its appearance.

Loss of Susceptibility

On the basis of available data, it appears that seasoned butchers and

inspectors are less troubled with this dermatitis than are novices. One report states that "constant exposure produces a partial immunity; however, it develops in seasoned workers from time to time." According to another report submitted by an inspector with years of experience, "older workers develop a gradual immunity to repeated attacks." The writer of the latter report states, "In my experience, immunity developed in the course of time." Other reports state that the affection is likely to develop in susceptible subjects after returning from their vacations.

While the evidence in favor of the acquisition of a gradual resistance is far from conclusive, it certainly indicates that certain persons tend to overcome their susceptibility in the course of time.

Predisposing Factors and Seasonal Occurrence

In addition to individual susceptibility, other predisposing factors are: continued contact with freshly killed carcasses; and inability to cleanse the hands frequently in running water, particularly cold water, in order to wash off the blood, peritoneal fluid, fat, and other fluids and tissues from carcasses, which tend to accumulate and adhere to the skin, particularly in the interdigital spaces.

Several reports contain definite statements to the effect that this dermatitis is more prevalent in winter than in summer; one report states that it is more acute in winter; another report, however, states that this skin affection is but little influenced by the season. Despite such flatly contradictory statements, the weight of evidence, as far as available data show, is in favor of the view that this dermatitis not only is more prevalent, but develops in a severer form, during the winter months than during the summer. The explanation offered for this phenomenon is that the kill is always heavier during the winter, resulting in longer exposure each day, with a smaller opportunity to wash the hands at frequent intervals. As a consequence, a greater opportunity is afforded for the absorption of fluids from the animal body, which presumably is responsible for the skin affection.

Treatment

Among the treatments that have been most frequently used for this dermatitis, with varying success, are the following: ointments, particularly zinc oxide, vaseline, leaf lard, various "creams," glycerin, and various hand lotions. Several correspondents state that they have been benefited by applying bichloride of mercury, using it as a wet dressing, in the form of an ointment, or merely soaking their hands in a solution of the chemical. Mild acids, such as vinegar and lemon juice, are said to produce relief from the itching which accompanies this skin affection. According to a report, one meat packing establishment provides a barrel of vinegar in which butchers dip their hands from time to time while at work. As will be shown in connection with prevention, frequent washing of the hands in cold running water is said to be beneficial in the early stages of this skin affection, when the fingers alone are involved. Many sufferers from this dermatitis apply

various dressings before retiring at night, and not uncommonly put on a pair of cloth gloves to prevent soiling the bed linen.

The available evidence indicates that while butchers' dermatitis may be relieved by the application of various remedies, no permanent cure can be effected so long as susceptible persons continue to handle the carcasses of meat food animals to which they are sensitized.

Prevention

Frequent washing of the hands in cold running water, with or without soap, while engaged in dressing, cleaning, inspecting, and performing other tasks in connection with freshly killed carcasses, appears to be one of the most effective prophylactic measures. There are numerous data to show that washing the hands in warm water aggravates this condition. Thorough washing and scrubbing of the hands with a brush, with particular attention to the interdigital spaces, at the end of the day's work, appears to be a well-recognized precautionary measure.

Apparently the accumulation of blood, serum, peritoneal fluid, fat, and other tissue in the webs between the fingers is considered to be the immediate exciting cause of this dermatitis. It also appears that warm water aggravates the condition, because it favors absorption and also because its solvent action on tissues is greater than that of cold water. One report states that when the viscera were passed under a spray of cold water before reaching the inspectors, and cold water became available for washing the hands, many persons markedly susceptible overcame the condition.

Case Histories

Following are excerpts from the correspondence submitted by inspectors of the Bureau of Animal Industry. These have been selected to illustrate what are considered to be rather typical case histories; Case 10 is rather atypical as far as the location of the lesions is concerned.

Case 1.—"I worked on the viscera bench at the hog house of Establishment X, in Chicago, for thirty days in 1927, when I discovered that I was a victim of a disease called 'hog itch,' which lasted for about six months and continued while I was on cattle assignment, alternated each month with the hog assignment. The cattle assignment did not seem to help the condition very much. Each morning after I had worked about thirty minutes, and warmed up, I noticed several red blotches the size of a pinhead forming between my fingers just under the skin. They caused me considerable annoyance due to intense itching and irritation. I continued to handle warm viscera and wash my hands in warm water; meanwhile the blotches between the fingers grew and filled with a clear fluid until some of them were the size of a match head.

"To get relief I would open the enlargements and let the fluid run out. The medicinal treatments used were simple remedies recommended by fellow veterinarians, such as sulphur ointment, lemon juice, and salt water, without material results. I washed my hands in cold water and this seemed to retard the intense itching and have a soothing effect. To this day, if for any reason I have to keep my hands in warm water a long time, I have a slight reaction, but the blotches disappear when I use the cold water treatment."

Case 2.—" 'Swine itch' does not affect me while working on hog viscera at this station, but occurs regularly during the weeks I am assigned to sheep and calf viscera and to cattle viscera. The condition is worse during the months that I am at Establishment X than during the period that I work in Establishment Y. The reason for this may be that only warm water is available

for washing hands at the viscera tables of Establishment X, while frequently washing the hands in cold water at Establishment Y seems to check the condition.

"I believe the vesicles, which appear first between my fingers, then on the backs of my hands and wrists, are due to the absorption by the water soaked skin of foreign proteids.

"The nightly application of spirits of camphor, or of salicylic acid in alcohol, tends to dry the vesicles, harden the skin, and lower its irritability."

CASE 3.—"I have always been affected by this condition when on postmortem work, especially when working long hours, which I believe is due to the fact that it is impossible to keep my hands free from blood and grease. The lesions are characterized by a reddening and swelling of the skin, with a burning and itching sensation at first, followed by vesicular eruptions. The hands are affected only between and on the backs of the fingers. Duration of symptoms and lesions is about four or five days with treatment, usually followed by a new attack in about fourteen days.

"I have consulted physicians from time to time about this condition, but they seem to be in the dark as to cause and treatment."

CASE 4.—"I entered the California State Meat Inspection Service in March, 1924; in less than two weeks I had developed a condition about the hands, particularly between the fingers, characterized by vesicular eruptions which caused intense itching, and this became so irritating that it caused me to rub the blisters until they bled and became very sore and painful.

"I consulted a physician in San Jose, Calif., who said it was a little dermatitis. I was soon transferred to Modesto, Calif.; the condition soon disappeared and did not occur again while I was in that town. After one year I was sent to Dixon, Calif.; in less than two weeks my hands, especially between the fingers, became very raw, sore, and painful, and very soon similar lesions broke out on the forehead and finally on the legs below the knees and around the ankles, until I was compelled to bandage the feet for fear of blood infection. I consulted a local physician who diagnosed the case as due to a poisonous pollen. However, after changing the treatment three times, he sent me to a doctor in Woodland, Calif., who said that he could cure it and had often seen it in the Philippine Islands, where it was common and known as the 'Dobie itch.'

"After prescribing various treatments, chiefly mercurial ointments, he admitted the condition was getting worse, and gave up. Another doctor, seeing the infection on the forehead, said it was the dye from the hat band.

"The first intimation I got as to the real cause of the trouble was given me by a federal inspector. He said it was the peritoneal fluids from cattle and told me to get a 10 per cent. ointment of ichthyol. This substance is greasy and is not absorbed readily. If application is made before retiring for the night, gloves should be worn to keep it off the bed clothes as it is brownish-black in color and very sticky. I believe this is the best remedy I have tried.

"After working in Dixon over three years, with the condition getting worse, having by this time appeared on the abdomen, legs, fingers, forehead, and even on the eyelids until the dry scales peeling off affected the sight, it became so extensive that it caused one sleepless night after another. I was transferred back to Modesto on April 1, 1928, and, strange as it may seem, I have not been bothered with this condition since. Although I had it in an aggravated form when I got here, it cleared up in ten days. I have been here fourteen months now and handle more meat than I ever have done before."

CASE 5.—"Whenever I work continuously in blood without being able to wash my hands frequently, I develop an itch on the hands, especially between the fingers. It develops as a reddening, swelling, drying and cracking of the skin. I have been troubled with very similar lesions when doing postmortems on cattle, but not as frequently as when doing postmortems on swine. I am able to wash my hands more frequently when working on the cattle floor than when working on the hog floor. The lesions respond to treatment with antiseptic ointment, whenever I am able to keep them out of the blood. There will be an improvement with just a rest over Sunday."

CASE 6.—"About six weeks ago I ex-

perienced a slight itching eruption between two fingers of the right hand. After a period of perhaps a week, the same manifestation appeared over the back of the same hand. At that time I left the plant for my vacation, during which time all symptoms of the eruption disappeared without treatment of any kind.

"Within two weeks of resuming work following my vacation, the eruptions again appeared on the left thumb and on both wrists, the area on both wrists being about the same size, as large as the palm of a hand, which condition still persists.

"During the day, while at work with hands and wrists wet, the slight eruptions are reddish and of a vesicular appearance, but by the next morning have diminished in size and color. The area affected is slowly increasing in size, with a tendency to spread further up both arms.

"I have been using a weak phenol solution as a wash, without any appreciable beneficial effects. However, I experience very little itching of the parts affected."

CASE 7.—"After working about four or five days on either 'hog viscera' or 'hog rail' inspection there would be a burning sensation on the fingers, which would last from one to two days. This would be followed by the appearance of vesicles. The extent and time required for the development would follow the ratio of the speed of the work performed.

"After about two weeks' work, the vesicles would not develop so rapidly for a time, but unless treatment was kept up they would continue to develop. The treatment I used was lemon juice. I would keep a slice of lemon handy and just rub it over the affected area four or five times daily. This relieved the burning sensation, and reduced the vesicles.

"When assigned to postmortem work on cattle a condition developed which I considered the same, and I have heard it often spoken of as 'cattle itch.' And I have seen butchers affected with a similar condition from working on sheep and it was spoken of as 'sheep itch.' Unless treatment was kept up I was never free from the 'itch' during the several years' time that I was assigned to postmortem work at the station."

CASE 8.—"The following is the result of personal experience and observation extending over a prolonged period of service. I have had repeated attacks confined to the hands and, in the course of time, an immunity seems to have been developed. The condition would yield readily to treatment within about a week or ten days. Several years ago I developed a well-marked dermatitis of this type confined to the hands while assigned exclusively to the postmortem inspection of sheep, and while no physician was employed it did not differ materially from previous attacks and was looked upon as the usual condition encountered by inspectors engaged in postmortem work. It is considered for the most part as a local affection not requiring the services of a physician.

"Inquiry was made of the establishment physician regarding any severe cases that may have come to his attention, and he advises that cases varying in severity come to him from time to time from among the various workers who either do or do not handle viscera, and he, therefore, does not look upon viscera as being the exclusive causative factor. A young man assigned to pulling the leaf fat and dropping the ham facings was treated recently by light rays with good results. This case had extensive lesions extending from the tips of the fingers to as far as the elbows, and both feet were also affected as well as the abdomen, the latter in a few well-defined patches."

CASE 9.—"During 1912 to 1915, while performing routine inspection, I suffered almost continuously with 'swine itch' or 'cattle itch,' at times the eczema extending halfway to the elbows. Conditions favoring development were these: hands continuously in blood with only extremely hot water to wash them in, and no time to cleanse them of fibrin frequently and thoroughly during work. It occurred during both swine and cattle inspection.

"Experience showed that a satisfactory way to treat them was to cleanse the hands frequently, using a mild soap and water not too warm, and an emollient at night. A few times I found it necessary to bandage the hands at night with a mild mercury bichloride pack, which brought quick relief on account of secondary infection."

CASE 10.—"Early in 1927 I was conscious

of an inflammation accompanied by an itching sensation in the axillary region of both arms. I thought at first that this was due to my clothing so I purchased extra large jackets to wear while doing postmortem work. No noticeable relief was obtained; therefore, upon the advice of a physician, I was compelled to take a few days' sick leave for the purpose of having the condition treated. The physician diagnosed the trouble as the vesicular form of eczema. His method of treating the condition was by the application of resorcinol ointment followed by a dry dressing of bismuth formic iodide.

"In a few days after resuming my duties I again noticed an intense inflammation of the skin under both arms and extending down both sides of my body from each axilla. During this attack and since then I have treated this condition myself. The treatment that I used consisted of the application of a zinc oxide-campho-phenique ointment. The affected parts were lightly washed with bichloride soap and water before the ointment was applied. But just recently I have commenced to paint the inflammatory areas with mercurochrome which seems to afford temporary relief for both the dermatitis and the itching sensation.

"In order to make sure that the condition was not eczema, I began to take notes on its periodic reappearance and found that the inflammation and itching sensation were most noticeable following postmortem work on swine. It is a very disagreeable condition, and it is almost impossible to effect a permanent cure especially while coming into actual contact with swine viscera. I have never been entirely free from it since the first attack but can keep it under control by the local application of medicines."

The following communication concerning butchers' dermatitis has been received from a physician employed by one of the largest meat packing establishments:

The following observations have come to our notice: First, this skin affection is not infectious, pointing to the fact that it may be simply an irritative dermatitis; secondly, in the offal department there is a tendency to more frequent skin afflictions which can probably be attributed to a chemical irritation.

The reason for this conclusion is that it clears up very shortly after susceptible individuals quit working; also, we have not seen other members in the family get this condition; and finally, ordinary, mild ointments give good results.

In the mild cases our treatment for the condition has been zinc oxide ointment with about 10 grains of salicylic acid to the ounce. We place vaseline over many fresh wounds, which tends to keep the water from irritating the individuals who are working in the casing and offal departments. This makes a practically waterproof dressing. In the very obstinate cases we have had very good success by long exposure to the ultraviolet ray; usually one or two treatments are sufficient. In the very severe cases, which are rather unusual, we have them stop working for a few days. We have never had a case that has alarmed us or did not respond to the above treatments.

Summary

The principal facts presented in the foregoing pages may be summarized briefly, as follows:

1. Butchers' dermatitis, characterized principally by erythematous areas on the hands followed by the appearance and subsequent eruption of pinhead vesicles, and accompanied by considerable itching as a symptom, is an occupational disease largely affecting butchers and inspectors who handle freshly killed carcasses.

2. The lesions, which first appear on the webs of the fingers and spread to the sides and backs of the fingers and to the backs of the hands as far as the wrists, may extend up the arms as far as the elbows, and in exceptional cases may spread to other parts of the body such as the chest, abdomen, legs, and face.

3. The affection does not appear immediately upon the exposure of susceptible persons, but usually makes its appearance after an initial period of exposure varying from three to thirty days, during which time susceptible persons presumably become sensitized to the tissues and fluids of swine, cattle, and sheep.

4. While certain persons make a rapid recovery following the first attack, with or without treatment, others develop repeated attacks while the exposure to the inciting cause is continued; in some persons the susceptibility lasts for several years.

5. The available evidence indicates that many seasoned workers lose their susceptibility to this affection in the course of time.

6. While most susceptible persons appear to become fairly equally sensitized to the various classes of meat food animals that are slaughtered in abattoirs, certain persons exhibit a specific susceptibility to one or two classes of these animals and are unaffected by contact with others.

7. The dermatitis may be checked by various local applications commonly used in treating related skin troubles in which there are no constitutional symptoms.

8. On the basis of available evidence, frequent washing of the hands in cold running water, thorough scrubbing of the hands with soap and brush at the end of the day's work, and coating the hands with vaseline or other ointments before beginning the day's work are, in most cases, effective prophylactic procedures.

A STUDY OF DYSMENORRHEA AT THE HOME OFFICE OF THE METROPOLITAN LIFE INSURANCE COMPANY*

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DYSMENORRHEA is one of the most controversial subjects in the field of gynecology. There are as many different theories regarding its etiology as there are methods of treatment, and consequently both the gynecologist and the general practitioner frequently are at a loss.

REVIEW OF LITERATURE

Standard textbooks are today devoting much more attention to dysmenorrhea than they did formerly. Graves (1), in his 1928 edition, gives three classifications: essential or primary dysmenorrhea; secondary or acquired dysmenorrhea; and membranous dysmenorrhea. The causes for essential dysmenorrhea, the type with which we are chiefly concerned, are malposition, hypoplasia, cicatricial band at the internal os, and hypertrophy of the endometrium.

Crossen (2) still uses the old classifications of neurologic or ovarian dysmenorrhea; congestive or inflammatory dysmenorrhea; obstructive or mechanical dysmenorrhea; and membranous dysmenorrhea. Treatment during menstruation consists in hot applications and sedatives. For so-called "nasal" dysmenorrhea he suggests cocainization of the "genital spot" in the nose. Between periods there should be a general building up of the patient, and glandular medication.

Eden and Lockyer (3) divide dysmenorrhea into the primary (intrinsic) and secondary (extrinsic) classifications, and give three causes for each group: for the primary group, uterine contraction, intrauterine clotting, and vasomotor disturbances; for the secondary group, inflammation of the ovaries and tubes, hemorrhagic cysts of the ovary, and interstitial or submucous fibroids. They believe that treatment should be preparatory and operative. Preparatory treatment consists in attention to the gastro-intestinal tract, hot baths, and sedatives.

Fulkerson (4) states that malposition of the uterus, with obstruction to discharge, is the most common cause of dysmenorrhea; in the absence of pelvic pathology causing obstruction, ovarian dysfunction is probably at fault. His method of treatment consists in symptomatic relief by medication, such as fluidextract of hydrastis and glandular medication for infantilism.

Cecil (5) gives only one classification which he calls primary dysmenorrhea. He believes that this is due to a mechanical obstruction of the cervical canal, to neuritic factors, and to hypoplasia of the uterus. Suggested

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treatment for primary dysmenorrhea is by glandular extracts.

A study of recent articles (6) (7) (8) (9) reveals classifications similar to those already noted. R. S. Statham (6) distinguishes four types: spasmodic or intrinsic (Blair Bell); congestive or extrinsic (Blair Bell); membranous; and mixed. The intrinsic type usually begins at puberty and is due to irregular contractions of a malformed uterus. The extrinsic type is due to influences outside of the uterus, such as ascending infection from gonorrhea or appendix infections.

Blair Bell, who was the first to divide dysmenorrhea into the extrinsic and intrinsic types, defines intrinsic dysmenorrhea as a condition in which the menstrual pain is due to some inherent abnormality of the organs of menstruation or of the physiologic process connected with the function. Polak (7) agrees with Blair Bell in his classification. He reports excellent results with small doses of radium in the very severe cases of intrinsic dysmenorrhea in which there is some abnormality of the wall of the uterus, such as fibroid rests.

Regardless of the cause of dysmenorrhea, the facts remain that it is a distinct clinical entity and that it causes a great deal of discomfort to the patient and a real loss of time and impairment of efficiency. This is particulary true in industrial organizations where a large number of women are employed.

Present Study

In a study carried on at the Home Office of the Metropolitan Life Insurance Company it was found that among its female clerks, numbering 7,390, there were 1,151 days of absence and 2,670 visits to the rest rooms from June to December, 1927, caused by dysmenorrhea. It was felt that an effort should be made to correct the situation so that some of these absences and visits could be avoided. Various members of the medical staff, working independently, had verified the fact that there is marked improvement in some cases of dysmenorrhea following regular systematic exercising. In April, 1928, it was therefore decided to make a study of the effect of exercise on cases of dysmenorrhea, in the hope not only of relieving much of the suffering, but also of increasing the efficiency of the employees.

The Medical Division of the Metropolitan Life Insurance Company was particularly adapted to such a study, as the patients could be observed during the period of treatment. This is difficult in clinics and in private practice, owing to the lack of co-operation on the part of the patients. No attempt has been made to classify the types of dysmenorrhea treated, as it was impossible to do pelvic examinations in every case. The majority of the cases, however, were probably of the primary or intrinsic group.

Method of Treatment

The patients selected for treatment were girls who were absent frequently or who had to spend several hours in the rest rooms at each menstrual period. Each girl was interviewed by the physician and a menstrual history taken, with special attention to the number of hours of discomfort, the location and kind of pain, leukorrhea, and constipation. Of the 523 patients, 190, or 36 per cent., admitted that they had leukorrhea, and about 50 per cent. stated that

they were constipated; practically none took any systematic exercises. A brief explanation of the pelvic anatomy and the factors causing dysmenorrhea, such as constipation and congestion, was given each patient, and the principle behind the treatment of dysmenorrhea itself was demonstrated. Whether there was a history of constipation or not, the necessity for regular bowel habits, proper diet, and fluid intake was emphasized. Mineral oil was advised frequently and a mild laxative was prescribed to be taken thirty-six hours before the period was due. The patient was referred to the physiotherapist for grading as to posture and for instruction in the exercises that were considered best for her.

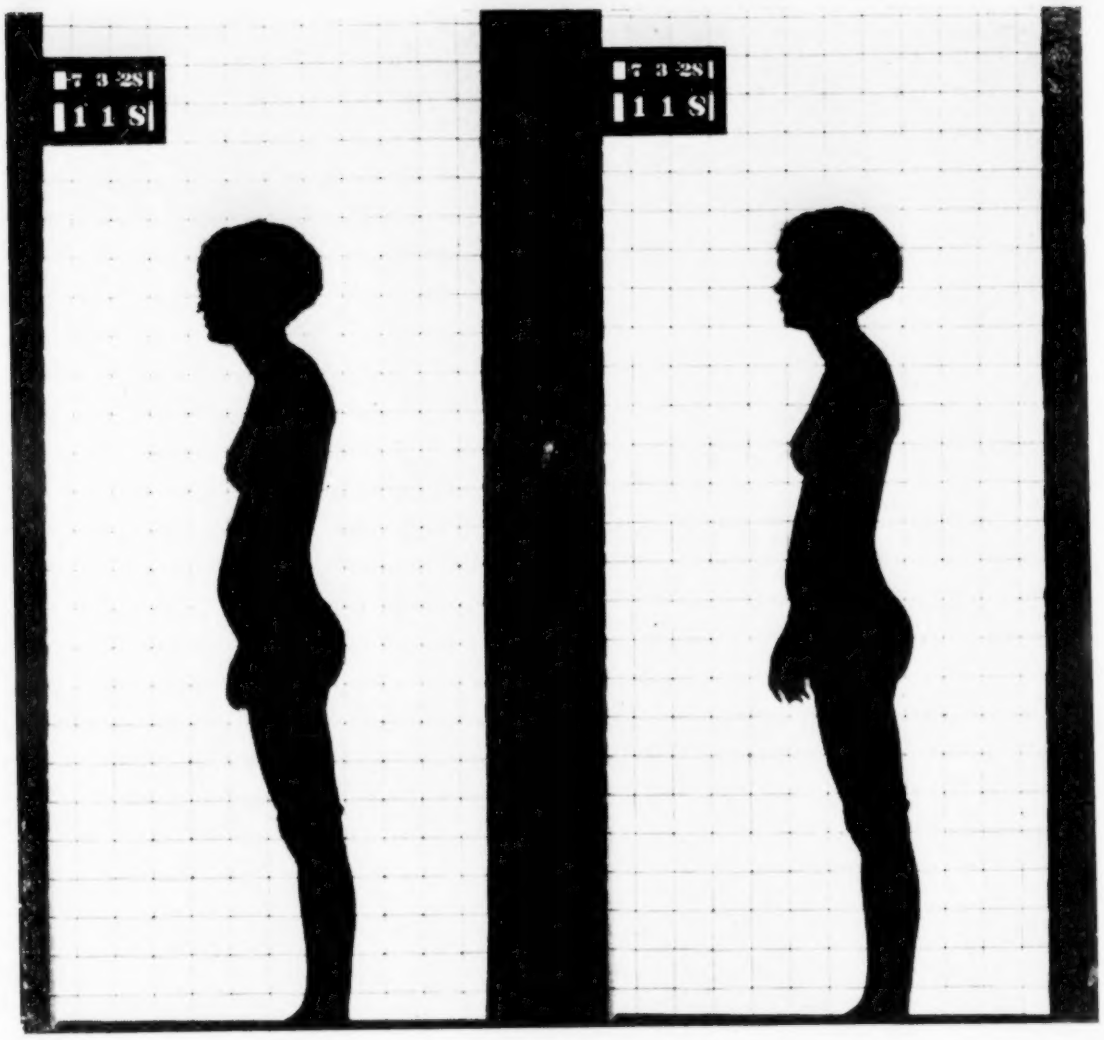
The postures were graded from a silhouette picture, on a percentage basis, and were divided into four groups according to their ratings: A, B, C, and D. (Each teacher has her own standard in the relative marking of these groups.) The following points were considered in grading: head, chest, dorsal curve, lumbar curve, abdomen, and weight distribution. The most common faults of poor posture are relaxed abdominal wall and exaggerated lumbar curve (see Figs. 1 and 2). Only 1 per cent. of the members of the group were graded A; 13 per cent. B; 82 per cent. C; and 4 per cent. D.

The girls reported to the physiotherapy department once a week for one or two months for a check-up on their exercises and posture, and were observed once a month by the physician. A careful record of each case was kept.

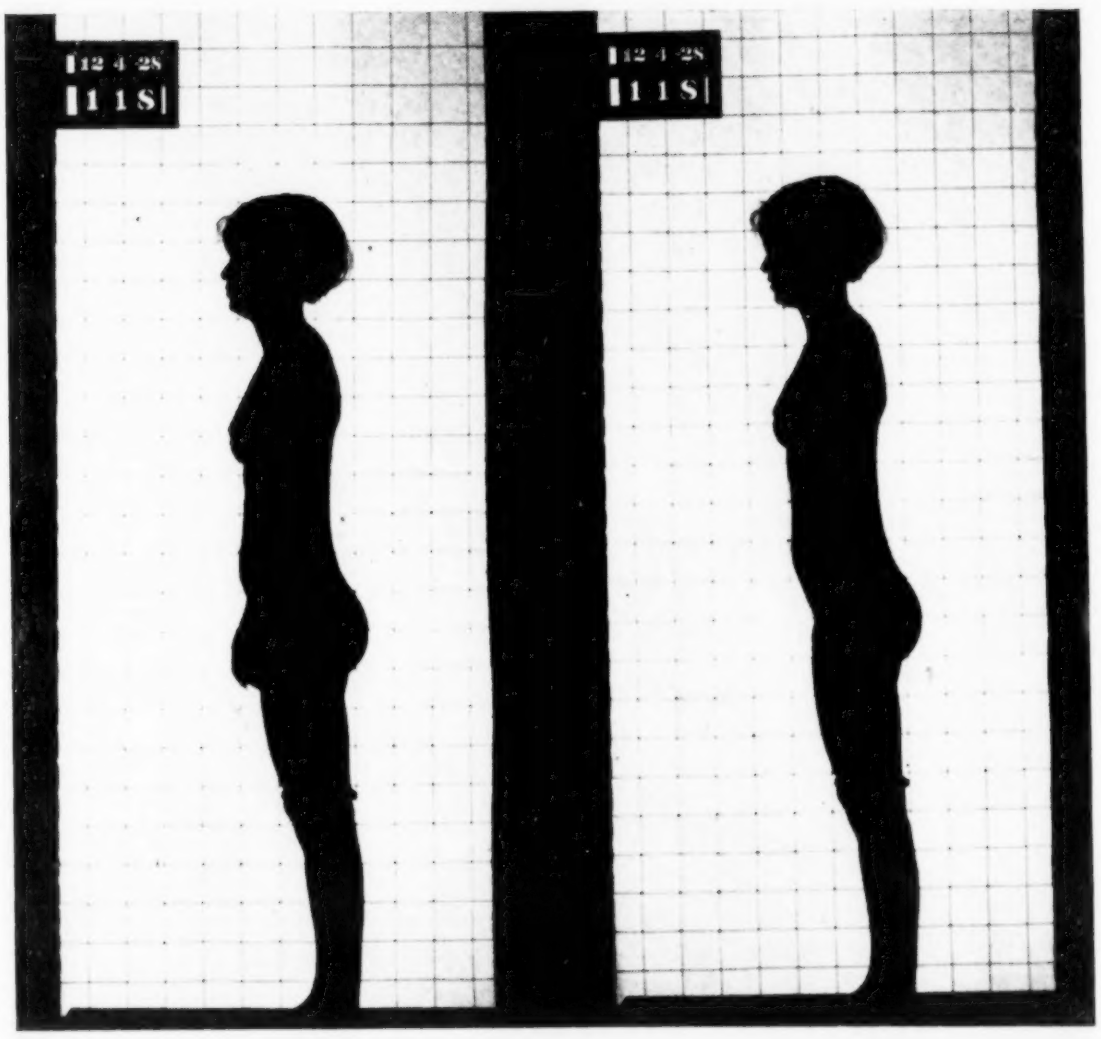
A pelvic examination (rectal or vaginal) was made on the patients who did not show some improvement in four months, and they were referred to their own physicians if gynecologic treatment was necessary. Those who had a normal pelvis, but still complained of dysmenorrhea, were kept under treatment and observation. Usually these were the girls who did not co-operate in carrying out instructions. Patients who had no pain for six months or more were discharged from observation as cured. For the most part it was from two to four months before improvement was noticed, and from about eight months to two years before the supervised exercises could be stopped.

Two special classes of supervised exercises were conducted for three months for very severe cases of dysmenorrhea, and it was found that these cases improved markedly when required to report daily. The exercises used were those suggested by Lillian C. Drew in her book entitled "Individual Gymnastics" (10). For the first three months of the study the Mosher exercise alone was used, in order to determine how much benefit might be derived without other treatment. Dr. Clelia Mosher claims exceptional results with this exercise, which consists in the contraction and expansion of the lower abdominal muscles, independent of breathing. Its function is to increase the circulation of the pelvis and to strengthen the abdominal muscles. In our experience the very mild cases cleared up entirely with the Mosher exercise, but the more severe ones were only slightly improved. Setting-up exercises were then added, starting with one or two simple ones and gradually working up to about eight, taken for ten minutes daily. The combination of the Mosher and setting-up exercises seemed to give the best results.

While 89 per cent. of the records

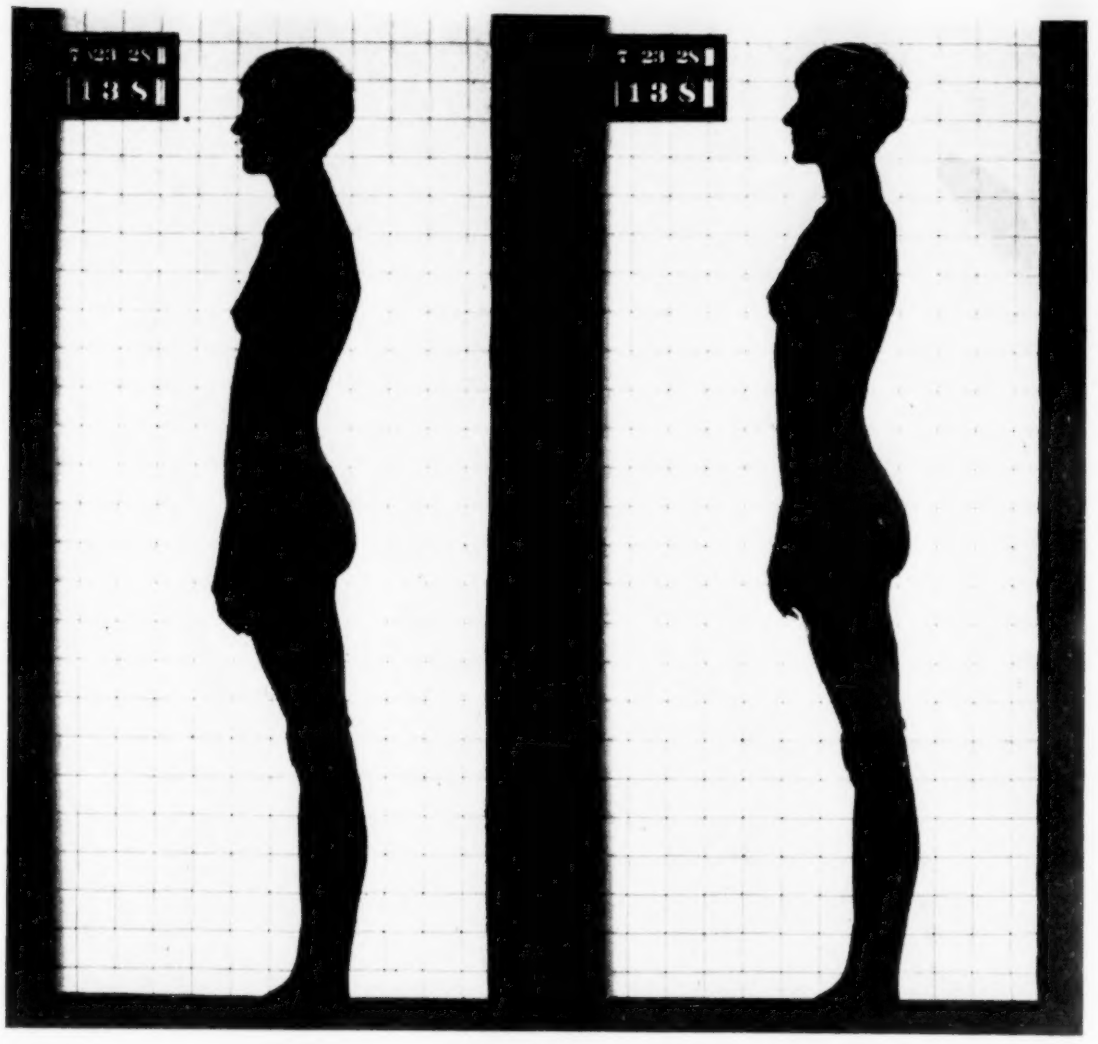


Before exercise.

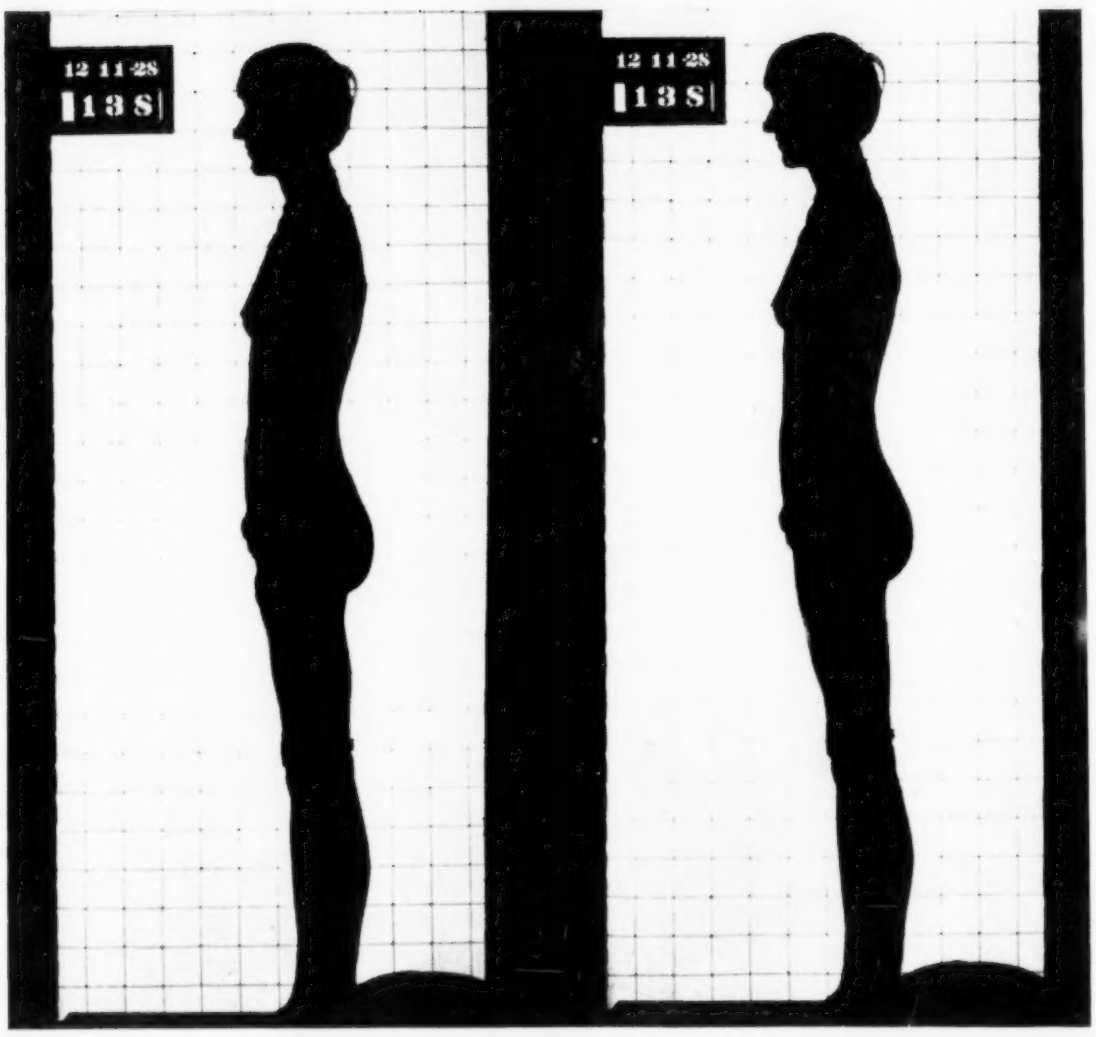


After exercise.

FIG. 1.—Showing posture of Subject T.M. before and after exercise.



Before exercise.



After exercise.

FIG. 2.—Showing posture of Subject N.F. before and after exercise.

showed improvement, it was thought that the reaction of the girls themselves might be interesting if they were given the opportunity to express themselves frankly and honestly. Accordingly a questionnaire was sent to each patient, with a request for an anonymous reply. Ninety per cent. stated that they had benefited by the treatment.

During this study practically no drugs were given routinely. With a small number (about twenty-five) of the more severe cases, pyramidon, gr. x every two hours, and prescriptions containing acetylsalicylic acid gr. iiss, acetphenetidin gr. iiss, and atropine gr. 1/600 were given every hour during the acute pain for two or three periods. About fifty patients were given glandular products—Burroughs Welcome Thyrovarium (thyroid gr.$\frac{1}{4}$, varium gr.v) and pituitary extract gr. ii b.i.d.—two weeks before the period. Eighty per cent. of the patients were definitely improved. The medication was always given in conjunction with the exercises.

Results

As a result of this work there has been a decrease in absences due to dysmenorrhea in the group of employees who were under treatment. Among 374 patients whose records were available for the six months prior to the first treatment and also for the subsequent six months, the amount of time lost decreased 53 per cent.; among 252 whose records were available for a full year before and after treatment, it decreased 52 per cent. In a few cases (seventy-five) the records were studied for two years prior to and subsequent to treatment; these showed a decrease in time lost amounting to 59 per cent.

In order to make certain that absences for dysmenorrhea were not attributed to other causes by the patients under treatment, a study was made of all their absences of one or two days. It was found that time lost for all short absences decreased about 30 per cent.; this was in keeping with the general decrease in short absences throughout the Company. Since the decrease noted for dysmenorrhea was so much more marked, we may conclude that the saving in time was a real and not an apparent saving, and that it was directly attributable to the treatment and observation of this group of employees.

TABLE 1.—AVERAGE NUMBER OF DAYS LOST AND AVERAGE NUMBER OF VISITS TO REST ROOMS PER MONTH PER 100 FEMALE EMPLOYEES, BECAUSE OF DYSMENORRHEA

JULY TO DECEMBER	AVERAGE PER MONTH PER 100 FEMALE EMPLOYEES	
	No. of Days Lost	No. of Visits to Rest Rooms
1924	3.0	7.1
1925	2.5	7.2
1926	2.6	5.5
1927	2.1	4.9
1928	1.3	3.3
1929	1.0	2.9
1930	0.6	2.3

The results of the work are also reflected in the decrease in absences and visits to the rest rooms for dysmenorrhea, among the total group of 7,390 female employees at the Home Office. This reduction in time lost is probably due to the direct results obtained among the few women treated, and to the indirect results of careful observation and

supervision of all absences for dysmenorrhea. Employees whose dysmenorrhea was slight were less apt to stay away from work when they knew that their absences would be noted and their history carefully checked. Then, too, the treatment given was discussed among the girls and in some cases was undertaken spontaneously without medical supervision.

Table 1 shows the number of days lost each month, per 100 females on the payroll, because of dysmenorrhea, and also the average number of visits to the medical rest rooms each month from July to December, 1924 to 1930.

Absences for dysmenorrhea have decreased from three days per month per 100 females in 1924 to about half a day per month in 1930, and visits to the rest rooms have dropped from 7.1 per month per 100 females in 1924 to 2.3 in 1930. If the average number of absences and visits had been the same in 1930 as in 1924, there would have been 250 clerk days lost per month instead of 46, and there would have been 587 visits to the rest rooms each month instead of 190; this indicates a very definite saving of time and relief of suffering.

There was a marked decrease in time lost between 1924 and 1927. In 1924 and 1925 no special effort was made to treat cases of dysmenorrhea, but in 1926 and 1927 different physicians of the staff, working independently, started treatment for severe cases. This may account for some of the decline from 1925 to 1928. It was not until April, 1928, however, that a concentrated study with careful tabulation of results was started.

Other factors must also be taken into consideration. Better hygiene, athletics, better health education of young girls and women, and personnel discipline in cases of frequent absence for any cause have undoubtedly aided in the decrease in time lost for dysmenorrhea.

Summary

1. Severe cases of dysmenorrhea (congestive and infantile type) can be improved, and about 50 per cent. can be cured.

2. The best results are obtained by using daily both the Mosher and setting-up exercises.

3. Constipation plays a large part in causing dysmenorrhea and necessitates careful regulation of diet.

4. Psychologic factors, such as self-discipline, also play a part in treatment for dysmenorrhea.

5. There has been a considerable saving in time lost, both from absences from work because of dysmenorrhea and from visits to the rest rooms at the Home Office of the Metropolitan Life Insurance Company, through the treatment of severe dysmenorrhea and through watchful supervision of the milder cases.

The posture studies were made by the Physiotherapy Department of the Metropolitan Life Insurance Company, Miss R. E. Hamilton in charge, and Miss C. O. Osley, assistant. The statistical work was done by Mrs. M. G. Stephens.

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OBSERVATIONS ON THE WORKING CAPACITY OF COAL MINERS IN RELATION TO ATMOSPHERIC CONDITIONS*

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SOME time ago (1), in conjunction with H. M. Vernon, we made a study of the influence of atmospheric conditions on the working capacity of coal miners. From the data at our disposal we concluded that the wet kata cooling power is a better index of atmospheric conditions in relation to working capacity than any other measure yet suggested.

As the result of his investigations on work at high temperatures, Haldane (2) (3) concluded that the endurable limit is governed by the wet bulb temperature, but that the limiting temperature is considerably raised if the work is done in a current of air. Although the limit of endurance appears to be governed by the wet bulb temperature regardless of the dry bulb, it does not necessarily follow that the latter has no influence on working capacity at temperatures well below the limit.

In their observations on native laborers in the Rand mines, Orenstein and Ireland (4) found that the mechanical work done by their subjects varied very closely with the cooling power of the air. An examination of their published data shows that the output of work was as closely correlated with the dry kata cooling power as with the wet.

The opinion has been expressed by T. D. Jones (5) that the efficiency of the human body at high temperatures depends more on the relative humidity than on the dry bulb temperature, and that a miner can work better at a dry bulb temperature of 100°F. and a wet bulb of 90° than in nearly saturated air at a temperature of 86°. In our opinion this statement is erroneous, and we are supported by the results of the present investigation. It seems wrong to assume that efficient work is necessarily impossible because the relative humidity is nearly 100 per cent. Saturated air at a temperature below that of the skin is warmed by contact with the body and its capacity for moisture is increased.

At the collieries where our previous observations were made, the air was of only moderate humidity, and we were not able to test the influence of very humid conditions. As it was thought desirable that we should endeavor to trace the effects of humidity on working capacity, we have since visited three other collieries where we have been able to make observations under more diverse conditions of humidity.

Method of Investigation

The measure of working capacity which is generally applied to industrial workers, namely, the measurement of

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output, cannot be used in comparing colliers working in different places. The variations in general working conditions, and in the difficulty of getting the coal, render output quite useless for this purpose. We therefore used the two tests described in the earlier report (see also Vernon (6)): *viz.*, a rest pause test and a tub filling time test.

As the result of observations in various heavy industries, it was found that the men invariably take short rests from work every few minutes, and that the more arduous the work, the longer and more frequent are the rests. They are taken spontaneously, and their duration probably affords some measure of the fatigue experienced (7). In this investigation we made systematic observations of all stoppages from active work, splitting up the rest pauses into two categories: (*a*) voluntary rests, and (*b*) involuntary rests (due mostly to the men waiting for tubs, and occasionally to a collier standing aside for a few moments to allow his mate to clear coal from his working position).

In investigations among persons whose work comprises a number of operations, each making up a variable part of the day's work, the method has been used of measuring the speed of performance of a single process as often as possible, and assuming that the results obtained are indicative of the speed of performance of the work in general. As a sample task in this inquiry we selected tub filling, and measured the speed with which this operation was performed. The speed of tub filling, however, was so much influenced by various factors other than the ability to do hard physical work that its use as a measure of working capacity had to be abandoned.

In each working place observations of the temperature and cooling power of the air were made at the working face in the position occupied by the collier when at work. The wet and dry bulb temperatures were taken by means of standardized Edney sling hygrometers.

In addition to the new data we have made use of those described in the earlier report, and altogether our observations relate to 304 men employed at five collieries. The men were always observed during the latter half of the day shift, and the average period of actual observation was ninety-seven minutes. The short meal interval, and any time when a man was absent from the working place (*e.g.*, fetching tubs), was ignored.

Duration of Rest Pauses in Relation to Atmospheric Conditions

The amount of time voluntarily taken for rests by the different men varied considerably, but the frequency with which various amounts of rest were taken was much the same at the different collieries. This will be seen from Table 1, in which we have shown the relative frequency with which the men at different groups of collieries took various amounts of voluntary rests. In order to exclude as far as possible the influence of rests taken involuntarily, these voluntary rests have been reckoned on the basis of possible working time. Thus, supposing a man took 4 minutes per hour in voluntary rests, and a further 10 minutes in involuntary rests, his

possible working time would be 60 — 10 = 50 minutes, and his voluntary rests per hour of possible working time would be $4 \times \frac{60}{50} = 4.8$ minutes.

The similarity in the amounts of rests taken by the men at the different collieries is also made clear when the voluntary rests per hour of possible working time are plotted against either dry kata or wet kata cooling power, as in Figure 1. In both diagrams the curves agree very well. The irregularity which appears at high dry kata cooling powers in the curve for collieries A and B is associated with small numbers of observations at these cooling powers. In view of such close agreement it is permissible to group all the observations together for further examination.

Correlation of Duration of Rests with Various Indexes of Atmospheric Conditions

Using these combined data, we have calculated the coefficients of correlation of the duration of total rests, and of voluntary rests per hour of possible working time, with various measures of atmospheric conditions. These coefficients are tabulated in Table 2.

Voluntary rests are significantly correlated with each of the indexes of atmospheric conditions except relative humidity. Total rests give sig-

TABLE 1.—PERCENTAGE OF MEN TAKING VARIOUS AMOUNTS OF VOLUNTARY RESTS

COLLIERY	NO. OF MEN OBSERVED	PERCENTAGE OF MEN WHO TOOK VOLUNTARY RESTS (PER HR. OF POSSIBLE WORKING TIME) AMOUNTING TO						
		Less than 4 Min.	4–5.9 Min.	6–7.9 Min.	8–9.9 Min.	10–11.9 Min.	12–13.9 Min.	14 Min. and Over
A and B	138	31	18	22	15	5	7	2
J and K	99	40	14	18	6	14	1	7
L	67	28	30	20	9	6	4	3

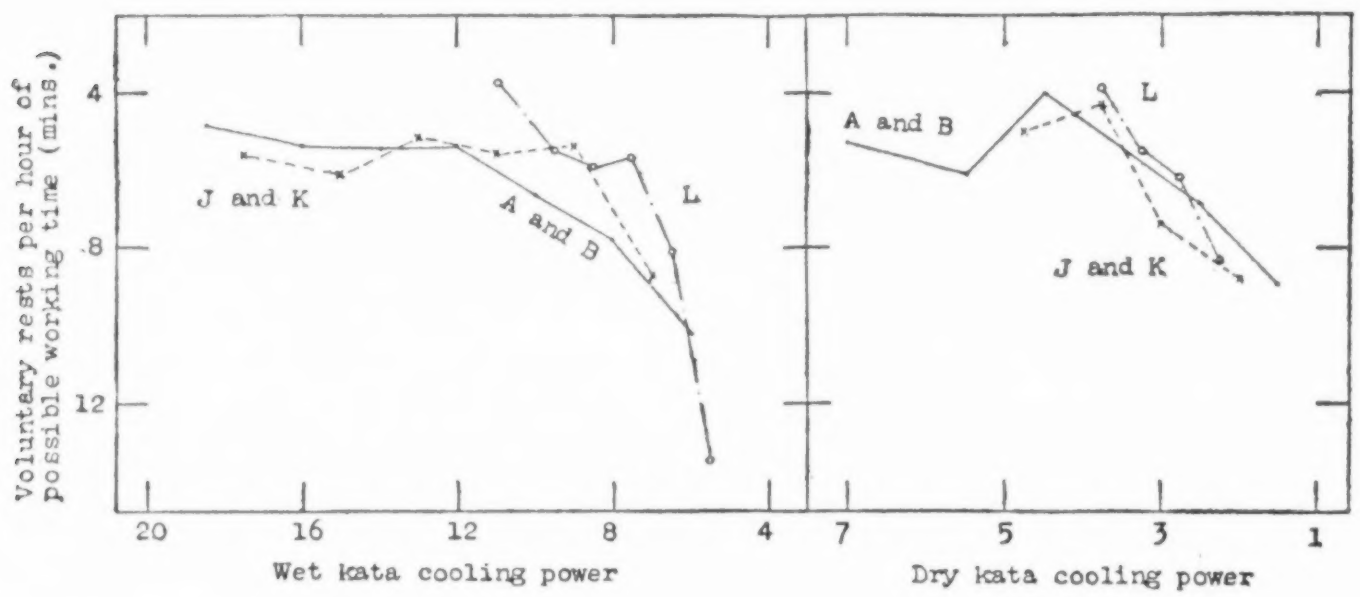

FIG. 1.—Voluntary rests in relation to cooling power.

nificant correlations with all except relative humidity and air velocity.

It might be argued that the increase in time which, as the correlations show, is taken for rests at low dry kata cooling powers and at high dry bulb temperatures, is due largely or entirely to the lower wet kata cooling powers or higher wet bulb temperatures which usually prevail under such conditions. One way of testing this point is by calculating partial correlation coefficients. Table 3 shows the partial correlations of rest pauses with dry kata cooling power and dry bulb temperature when wet kata cooling power is kept constant. These correlations are all significant, and indicate that when the wet kata cooling power is kept constant, a fall in the dry kata cooling power, or a rise in the dry bulb temperature, is definitely associated with an increase in the amount of time taken for rests. On the other hand, when the dry kata cooling power was kept constant, the correlations with wet kata were quite insignificant:

Voluntary rests per hr. of possible working time.....$r = -0.033 \pm 0.039$
Total rests per hr..$r = +0.041 \pm 0.039$

The correlation coefficients which have been adduced are all small. Those which have been mentioned as

TABLE 2.—TOTAL CORRELATIONS OF DURATION OF REST PAUSES WITH ATMOSPHERIC CONDITIONS

CORRELATED WITH	VOLUNTARY RESTS PER HR. OF POSSIBLE WORKING TIME	TOTAL RESTS PER HR.
Dry kata cooling power	−0.238 ±0.037	−0.232 ±0.037
Dry bulb temperature	+0.194 ±0.037	+0.270 ±0.036
Basic effective temperature	+0.207 ±0.037	+0.235 ±0.037
Wet bulb temperature	+0.191 ±0.037	+0.197 ±0.037
Wet kata cooling power	−0.204 ±0.037	−0.154 ±0.038
Air velocity	−0.113 ±0.038	+0.001 ±0.039
Relative humidity	−0.010 ±0.039	−0.074 ±0.038
Absolute humidity (grains of water vapor per pound of dry air)	+0.156 ±0.038	+0.147 ±0.038
No. of observations	304	304

TABLE 3.—PARTIAL CORRELATIONS OF DURATION OF REST PAUSES WITH DRY KATA COOLING POWER AND DRY BULB TEMPERATURE (WET KATA COOLING POWER CONSTANT)

CORRELATED WITH	VOLUNTARY RESTS PER HR. OF POSSIBLE WORKING TIME	TOTAL RESTS PER HR.
Dry kata cooling power	−0.129 ±0.038	−0.180 ±0.037
Dry bulb temperature	+0.115 ±0.038	+0.227 ±0.037

significant show that under certain conditions men will, on the average, take more or less time for resting than under other conditions; the association is not a very close one, however, probably owing to the many other factors involved besides atmospheric conditions. The coefficients are too small to enable one to predict the amount of time that will be taken for rests under any given set of atmospheric conditions.

Influence of Relative Humidity

The insignificant correlations of wet kata cooling power with rest pauses, when the dry kata is kept constant, suggest that if linearity of regression can be assumed, the influence exerted by the relative humidity is trivial. For the purpose of calculating the relative humidity we have used tables given by J. S. Jones (8). These tables are calculated for different barometric pressures, and by means of them we have been able to make allowance for the different depths of the various workings that we visited.

In Table 4 we have taken those of our observations in which the dry kata cooling power was from 2 to 3.9, and have grouped them according to the relative humidity. The observations at lower and higher cooling powers could not well be utilized as they were very unevenly distributed over the range of humidity, but we have been able to include 223 out of the total of 304 observations. It will be seen that there is no regular increase in rest pauses as the relative humidity increases. The amount of time taken for rests was only slightly longer at the highest humidities than at the lowest, even though the wet kata cooling power decreased from 14.2 to 8.8, and the wet bulb temperature rose from 69.8° to 78.4°.

In the same way we have classified all those observations in which the dry bulb temperature was 76° or more, so as to show any influence of relative

TABLE 4.—DURATION OF REST PAUSES IN RELATION TO RELATIVE HUMIDITY (AT DRY KATA COOLING POWERS OF 2 TO 3.9)

RANGE OF RELATIVE HUMIDITY	NO. OF MEN OBSERVED	DURATION OF RESTS PER HR.			VOLUNTARY RESTS PER HR. OF POSSIBLE WORKING TIME	TEMPERATURE		RELATIVE HUMIDITY	COOLING POWER		AIR VELOCITY
		Voluntary	Involuntary	Total		Dry Bulb	Wet Bulb		Dry	Wet	
%		*min.*	*min.*	*min.*	*min.*	°F.	°F.	%			*ft./min.*
Under 60	19	5.0	6.4	11.4	5.6	81.4	69.8	55	3.4	14.2	50
60–69	29	4.4	9.1	13.5	5.2	84.3	74.7	63	2.6	11.8	45
70–79	47	6.6	6.6	13.2	7.4	81.7	75.4	74	2.8	10.6	33
80–89	54	5.8	5.9	11.7	6.4	79.2	75.6	85	3.1	9.7	22
90 and over	74	5.4	7.1	12.5	6.1	78.9	78.4	98	3.1	8.8	20

humidity with temperature constant (Table 5). At temperatures of less than 80° there was no increase in the length of time taken for resting at the highest humidities. At temperatures of 80° or more, the length of time taken in voluntary rests increased with shortest voluntary rest time, and *vice versa*. The mean values of the two temperature groups show that more time was taken for voluntary rests at humidities of 70 per cent. or more, than at lower humidities, but here again the longer rests are asso-

TABLE 5.—DURATION OF REST PAUSES IN RELATION TO RELATIVE HUMIDITY (ON BASIS OF DRY BULB TEMPERATURE)

RANGE OF RELATIVE HUMIDITY	DRY BULB TEMPERATURE	NO. OF MEN OBSERVED	DURATION OF RESTS PER HR.			VOLUNTARY RESTS PER HR. OF POSSIBLE WORKING TIME	TEMPERATURE		RELATIVE HUMIDITY	COOLING POWER		AIR VELOCITY
			Voluntary	Involuntary	Total		Dry Bulb	Wet Bulb		Dry	Wet	
%	°F.		*min.*	*min.*	*min.*	*min.*	°F.	°F.	%			*ft./min.*
Under 60.....	76–79.9	13	4.7	10.1	14.8	5.7	78.6	67.4	55	4.0	15.7	54
	80 and over	10	4.8	5.1	9.9	5.2	83.7	72.0	56	2.9	13.7	58
	Mean	(23)	4.8	7.6	12.4	5.5	81.2	69.7	56	3.5	14.7	56
60–69.....	76–79.9	24	4.7	9.0	13.7	5.5	78.8	69.9	64	4.5	16.2	86
	80 and over	44	4.9	10.7	15.6	6.0	85.1	75.7	64	2.4	10.8	46
	Mean	(68)	4.8	9.9	14.7	5.8	82.0	72.8	64	3.5	13.5	66
70–79.....	76–79.9	12	7.1	2.6	9.7	7.4	77.8	72.3	76	3.2	11.5	17
	80 and over	38	6.5	7.9	14.4	7.5	83.6	77.2	74	2.6	9.9	37
	Mean	(50)	6.8	5.3	12.1	7.5	80.7	74.8	75	2.9	10.7	27
80–89.....	76–79.9	31	4.2	3.3	7.5	4.4	77.7	74.4	85	3.3	10.4	21
	80 and over	26	7.9	13.8	21.7	10.3	84.3	80.1	83	2.2	7.7	22
	Mean	(57)	6.1	8.6	14.6	7.4	81.0	77.3	84	2.8	9.1	22
90 and over..	76–79.9	51	4.8	8.8	13.6	5.6	77.5	77.0	98	3.3	9.4	18
	80 and over	21	7.0	3.5	10.5	7.4	82.6	82.0	98	2.6	7.4	26
	Mean	(72)	5.9	6.2	12.1	6.5	80.1	79.5	98	3.0	8.4	22

increasing humidity, but there was a setback in the highest humidity group. It is possible that the increase observed in the duration of rests may be due to the influence of somewhat lower dry kata cooling powers, for in this temperature group the highest cooling power was associated with the ciated with lower dry kata cooling powers.

In view of the variable nature of the data in Tables 4 and 5, and of the insignificant correlations of relative humidity with the duration of rest pauses which are recorded in Table 2, no inference can be drawn as to any

sensible effect of the relative humidity on the amount of time taken in rest pauses.

Influence of Absolute Humidity

From a physiologic standpoint, the *absolute* humidity is of greater importance than the relative humidity. The amount of moisture that can be evaporated from the body surface depends on the difference between the actual water content of the air and the water content of air saturated at the temperature of the skin. The difference between these quantities is known as the "physiologic saturation deficit."

As a measure of the absolute humidity we have taken the weight of water vapor (in grains) associated with a pound of dry air. These values have been ascertained from the tables prepared by J. S. Jones (8).

It has already been seen from Table 2 that rest pauses are significantly correlated with absolute humidity, the tendency being for more time to be taken in rests the greater the amount of moisture in the air. However, this apparent effect of the absolute humidity appears to be due to the association of low dry kata cooling powers with high moisture content, for when the dry kata cooling power is kept constant, the absolute humidity of the air appears to have no definite effect. The partial correlations of rest pauses with absolute humidity (dry kata cooling power constant) are quite insignificant:

Voluntary rests per hr. of possible working time.....$r = +0.001 \pm 0.039$
Total rests per hr..$r = -0.006 \pm 0.039$

Practical Conclusions

Our observations demonstrate the importance of the dry bulb factor in atmospheric conditions as far as they relate to the working capacity of coal miners. The amount of time taken in rest pauses is more closely related to the dry bulb temperature and the dry kata cooling power than to the wet kata cooling power. With a constant wet kata cooling power, a lowering of the dry kata cooling power is accompanied by an increase in the amount of time taken for resting.

These results are not in agreement with the opinion usually accepted. It has generally been assumed that Haldane's conclusions regarding the influence of the wet bulb temperature on the *limit of endurance* at high atmospheric temperatures apply also to variations of the working capacity of men exposed indeed to high temperatures, but under conditions well below the limit of endurance. The observations described above suggest that this generalization of the original finding is not justified. Indeed, they suggest rather that as an index of working capacity, the dry kata cooling power, or the dry bulb temperature, is more useful than any other simple measure. The human body, being of considerably higher temperature than the maximum wet bulb temperatures experienced in our present observations, was always able to evaporate enough moisture from its surface to keep down the body temperature to reasonably comfortable limits. There was never in our observations any close approach to extreme temperature conditions, when the wet bulb temperature is undoubtedly the limiting factor.

Arguing from the results of these observations, it seems that in some cases it might be possible to improve the working conditions by saturating the air with moisture. Such a procedure would, theoretically, reduce the dry bulb temperature to the same level as the wet bulb, the latter remaining unaltered; thus in a hot, dry mine, a considerable increase in the dry kata cooling power would be obtained.

Experiment in Artificial Humidification

In order to test the foregoing conclusions, an experiment in local air conditioning underground, by means of artificial humidification, was carried out at a certain colliery (9). The same groups of men were observed systematically (*a*) under normal atmospheric conditions, and (*b*) when the air was humidified. The experiment extended over eight weeks. For the first and third fortnights the normal atmospheric conditions prevailed; during the second and fourth fortnights the air was humidified as it reached the coal face.

At the outset it was realized that after being humidified, the air would be rewarmed by contact with the rock surface. During the experiment it was found that the air warmed up more quickly than was anticipated. Although, when humidified, the air reached the coal face 7° cooler than under normal conditions, after 35 yards of face had been traversed the cooling effect was reduced to about 2°, and further along the face the effect was barely noticeable.

Partly on account of this rapid loss of the cooling effect of conditioning, and partly owing to certain unforeseen and unavoidable circumstances, the results of the experiment were, practically speaking, completely negative.

Under actual mining conditions the factors influencing the rate of working are so complex that it is difficult, if not impossible, to obtain data which will enable the relative influences of the dry and wet bulb factors to be accurately assessed. It is desirable that the matter should be further investigated under laboratory conditions, in order that our conclusions may be put to a more stringent test, and the relative importance of the dry and wet bulb factors at different temperatures ascertained.

Summary

The influence of atmospheric conditions on working capacity was measured by noting the duration of rest pauses taken from work. Observations were made on 304 men for an average period of ninety-seven minutes each, or for a total of nearly 500 working hours.

The amount of time taken for rests was more closely associated with the dry bulb factor than with the wet. With wet kata cooling power constant, a reduction in the dry kata cooling power was accompanied by an increase in the length of time taken voluntarily for rests; but with a constant dry kata cooling power variations in the wet kata had no effect. These statements are based on an examination of correlation coefficients calculated from data relating to a considerable number of men, and they indicate that on the average, certain results may be expected. The association between rest pauses and atmospheric conditions is

not a very close one, and does not enable one to forecast what amount of rest any particular miner, or small body of miners, would take under given atmospheric conditions. There are evidently other factors which have a more powerful influence on production than atmospheric conditions, and which might nullify the good effects of any improvement in these conditions.

Neither the relative nor the absolute humidity of the air seems to have any definite effect on the amount of time taken for rests when the dry kata cooling power is kept constant.

The observations suggested that in a hot, dry mine, working conditions might be improved by the use of artificial humidification. An experiment in this method of air conditioning was carried out, but owing to certain unforeseen and unavoidable circumstances, the results were, practically speaking, completely negative.

It is concluded that if the relative influences of the dry and wet bulb factors on working capacity are to be accurately assessed, the matter must be investigated under laboratory conditions.

We wish to express our warmest thanks to the managements of the various collieries which we visited. At the expense of considerable time and trouble they always gave us their willing assistance.

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A NEW INSTRUMENT FOR MEASURING COOLING POWER: THE COOLOMETER*

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THE measurement of the cooling power of an environment on a solid body maintained at constant temperature is of interest to physiologists and to those who employ labor in hot atmospheres.

The subject of cooling has attracted the attention of scientists for many years. In 1804 Sir John Leslie (1) determined the variation in cooling caused by change in air velocity, by whirling a heated ball on a string. He also designed a thermometer which, as far as can be judged from the description, is identical with the modern kata-thermometer except for the calibration. It was used apparently only as an anemometer.

The familiar kata-thermometer designed by Sir Leonard Hill has rendered great service. Originally an instrument in which the cooling rate was determined by measuring the time taken for the liquid in the capillary to drop from one level to another, it has in one case been modified by inserting a heating coil in the bulb and holding the temperature constant (2).

Mercury thermometers and hot wires have been used.

Dr. Hill describes briefly an electrical instrument designed by himself and Mr. O. W. Griffith, in which the cooling element formed one leg of a Wheatstone bridge (3).

The liquid thermometer type of instrument, in which the cooling rate is determined by measuring the time required for the instrument to cool from one thermal level to another, has certain disadvantages. A decided thermal gradient is necessary to cause the heat to pass to the surface, whence it can be handed on to the environment; thus the surface temperature is determined by a heat balance such that the heat that flows to it can be passed on. This temperature is not constant and the thermometer does not give it. The liquid in the capillary may be caused to drop to a certain level either by cooling a portion of the liquid close to the glass a given number of degrees or by cooling all the liquid a lesser number of degrees. Heat moves inside the bulb both by conduction and convection. For these reasons it is difficult to understand just what is meant when the temperature of the instrument is referred to.

In the design of an instrument the following characteristics seem desirable:

1. The temperature at some point in the instrument should be known.
2. A negligible difference in temperature should exist between the cooling surface and the point where the temperature is measured.

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3. The surface should be maintained at constant temperature.

4. It should be possible to use the instrument as a black or a reflecting body for the study of radiation.

5. It should be possible to apply recording devices to the instrument.

Principle of New Instrument

A copper spool about 2 inches in length and 1 inch in outside diameter is wound with small copper and manganin wires to constitute a combined heating coil and resistance thermometer. Over the spool is slipped a thin copper shell, to constitute the cooling surface. The type of resistance thermometer selected was developed by Mr. Charles G. Maier of the United States Bureau of Mines (4).

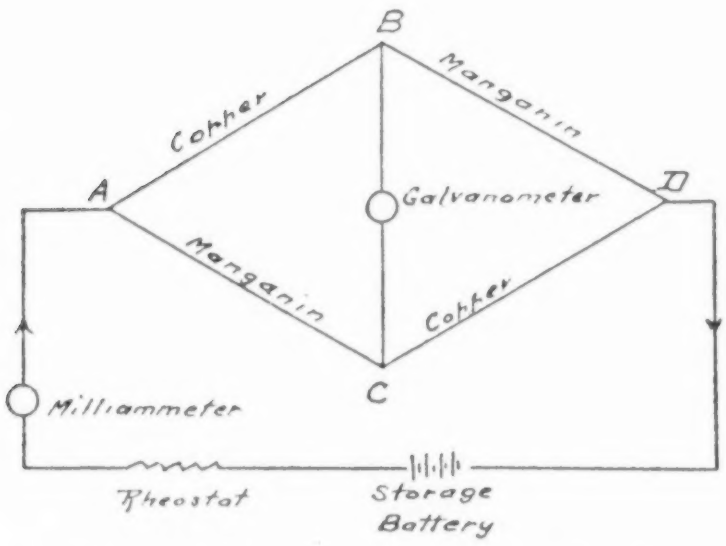

Fig. 1.—Diagram of electric circuit.

The diagram of the electric circuit is shown in Figure 1. Current supplied by a storage battery enters at *A* and leaves at *D*. The manganin wire has a negligible temperature coefficient, while the resistance of the copper increases with the temperature. The present instrument operates at a temperature of 37°C., or 98.6° F., but it may be adjusted to operate at any temperature. The lengths of the wires are so apportioned that when the desired temperature is reached, the resistances bear the following relations:

$$\frac{AB}{BD} = \frac{AC}{CD}$$

When the resistances are in this relation, a sensitive galvanometer across *BC* shows no deflection.

To operate, the current is turned on and adjusted by a rheostat until no difference in potential exists between points *B* and *C*. The current input is read on a milliammeter. Since the resistance of the circuit on the spool is known, the heat input per second can be calculated, and this divided by the area of the cooling surface gives the rate of cooling per unit of area.

An instrument was constructed in the fall of 1930 in order to test the feasibility of the idea. Mr. Fred G. Low, a student in the College of Mining, and Mr. C. M. Bell, a mechanic, aided in the construction of this instrument. With this experience at hand I designed the instrument shown in Figures 2 and 3. Figure 2 shows the spool with the wiring, and Figure 3 the instrument ready for operation. The spool is hollow. The lowest coil is of enameled copper, the next manganin, the next copper, and the top manganin. At the operating temperature the resistances of all the coils are the same; therefore the same amount of heat is generated in each section of the spool. Ample metallic paths for heat flow to the shell are provided by large flanges on the spool. The heat paths are designed so that a negligible temperature gradient exists between the wires and the shell. Over each of three of the coils are placed mica and a band of copper. The current and potential leads are soldered to the bands and the

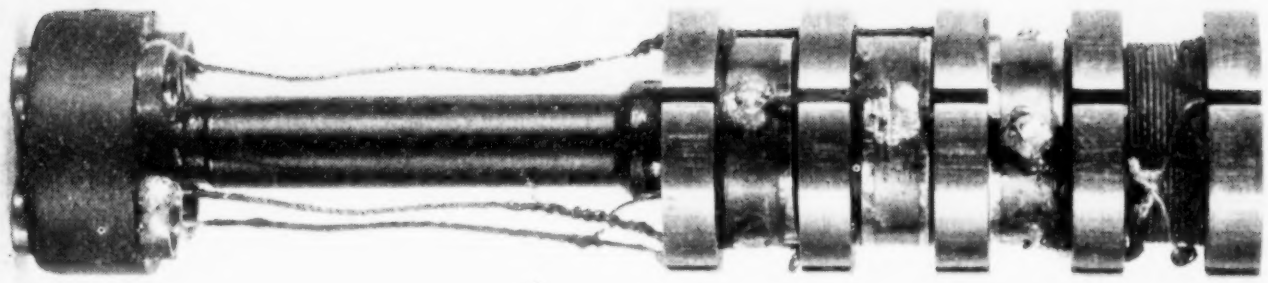

FIG. 2.—Interior of coolometer.

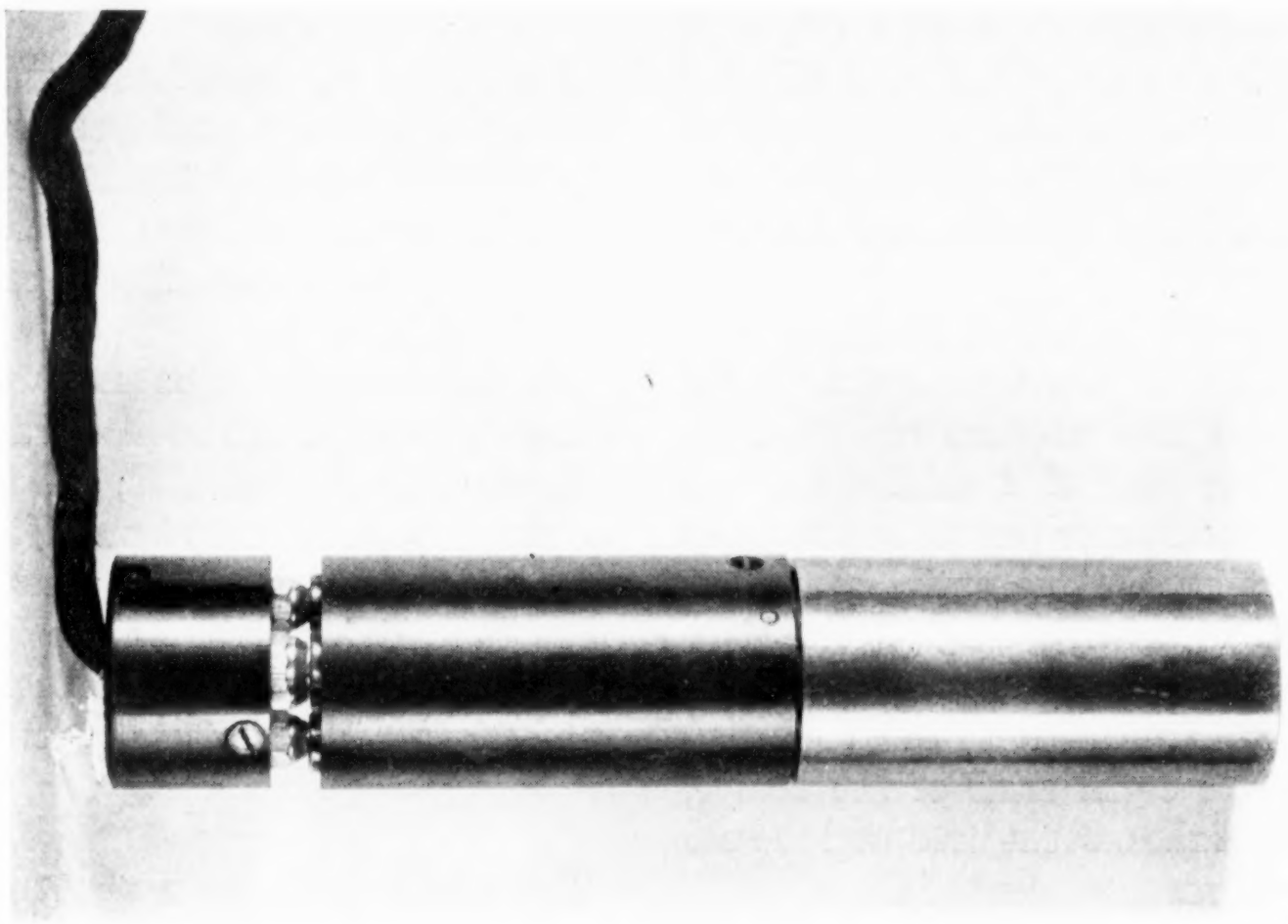

FIG. 3.—Coolometer ready for operation.

coils are also connected to the bands, to constitute the proper circuit. The leads are brought downward through the slots, as shown, and soldered to the sockets. The small stem is of hollow bakelite and is screwed into the

spool. The socket base is of hard rubber.

After the wires were adjusted and the resistance of the circuit was measured with the temperature at 37°C., the cooling surface shell, which was ground to fit the spool, was slipped on. A bakelite shell was then put on to cover the lead wires. Melted beeswax was then poured through a socket hole to fill the bakelite shell and to prevent heat loss from the side of the leads and the lower end of the spool. Beeswax has an extremely low heat conductivity. The beeswax fills the small space between the copper and the bakelite shells. A flexible four-conductor cable leading to the four-plug contacts completes the instrument.

The entire electric circuit upon which the accuracy depends is in the instrument and when once adjusted, which is an easy operation, it will stay in adjustment. Nothing depends on the resistance of the leads, which are often subjected to mechanical deformation.

For a cooling rate of 18 millicalories per square centimeter per second, 2.5 volts and 1.74 amperes are required. A cooling rate of 1 millicalorie per square centimeter per second requires 0.41 amperes. The entire current is utilized in heating the instrument.

Several factors contribute to the temperature sensitivity of the instrument—the equal arms of the bridge, the size of the current used, and the use of Maier's arrangement of the wires.

By means of a suitable galvanometer in which 1 division is 2 microamperes, the temperature of the instrument can be held constant to 0.006°C. when the cooling rate is 1 millicalorie per square centimeter per second, and to 0.002°C. when the rate is 18 millicalories per square centimeter per second.

By using a milliammeter for current measurement, cooling power can be measured within 0.052 millicalories per square centimeter per second when the cooling rate is 18, and within 0.013 millicalories per square centimeter per second when the cooling rate is 1.

The weight of the copper seems to be no barrier to the rapid action of the instrument. A mere wave of the hand will throw the galvanometer needle off center.

For the measurement of radiation two shells are used, one a reflector and one coated to make it a black body. The difference between the cooling powers with the reflector and the black body shells is the net radiation received or given out.

For use as an anemometer the reflector shell must be employed because the film coefficient of conduction (5) is the factor that varies with velocity, and consequently radiation exchange must be eliminated.

The instrument can be used wet, as it is waterproof; it can be placed at any distance from the operator; and it can be made recording by providing a mechanism to change the resistance when the galvanometer needle leaves the zero point, and by using a recording ammeter to read cooling power.

Summary

The paper describes a new instrument of great sensitivity for measuring the cooling power of an environment. Its essentials are a copper spool covered with a copper shell, the spool being wound with heating coils which constitute also an electrical thermometer

operating on the null principle to hold the desired temperature. The current input when the desired temperature is reached gives the rate of cooling, when combined properly with the constants of the instrument. The instrument can be operated as a reflecting or a black body, and thus can be used to study radiation. With the reflecting surface it can be used as an anemometer. Its construction is such that recording devices can be applied. It can be operated dry, or covered with a wet wick.

I am indebted to Mr. Charles G. Maier, Mr. C. T. Anderson, and Mr. K. K. Kelley of the United States Bureau of Mines for fruitful discussion during the experimentation, and to Mr. George Spencer, the mechanic who made the instrument.

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BOOK REVIEW

MINE ATMOSPHERES. By *William Payman*, D.Sc., Ph.D., M.Sc. (Tech.), Principal Assistant, Safety in Mines Research Board; and *I. C. F. Statham*, B.Eng., M.I.Min.E., F.G.S., Professor of Mining in the University of Sheffield. Cloth. Pp. 336 with diagrams and index. London: Methuen & Co., Ltd., 1930.

A wealth of information has been condensed into small compass in this textbook, which is one of a series of monographs on coal mining published by Methuen. The range covered can best be indicated by mentioning the chapter headings. *Part I*, on mine atmospheres, deals with the atmosphere, mine gases, heat and moisture, the physiologic effects of heat and moisture, the ignition of fire damp, fire damp explosions, mine dusts, and respiratory protection. *Part II* deals with the detection of inflammable and noxious gases, the sampling and analysis of mine air and mine dusts, and the influence of mine fires and spontaneous combustion on the mine atmosphere.

The data have been culled from a large number of official reports and papers published in scientific and technical journals, and in collecting the results of the various investigations the authors have produced a book which should prove valuable to all interested in the study of mining problems. From the range of subjects included it is obvious that the treatment cannot be exhaustive, but the salient points are clearly brought out, and references to the original papers are given throughout the book.

So far as we are competent to judge, the subjects of fire damp, explosions, and mine fires are dealt with in an admirable manner, and various types of apparatus for respiratory protection are clearly described. The sections on the detection of inflammable gases, mine air analysis, and the sampling and analysis of mine dusts are also well done.

In their references to the physiologic effects of mine atmospheres, the authors are rather less fortunate. On page 5 we read that "the physiological effects of water vapour in air depend more upon the degree of saturation than upon the absolute quantity of water contained in unit volume of air. . . . ." Later, on page 101, it is said that "if the atmosphere is saturated with water vapour, it cannot take up any further moisture. With such an atmosphere there can be no evaporation of sweat from the skin, so that the production of sweat does not serve to cool the body. The evaporation will depend upon the degree of saturation of the atmosphere. . . ." These statements are quite inaccurate. So far as the evaporation of sweat is concerned, the quantity that matters is the physiologic saturation deficit. Even if the atmosphere is saturated, sweat can still be evaporated if the air temperature is below that of the body surface, for the air in contact with the body becomes warmed, and its capacity for moisture is thus increased. The passages quoted illustrate the importance which is still attached to

relative humidity in mining circles. In the same section the authors quote Haldane's conclusion that the air temperature and the relative humidity influence body temperature only in so far as they affect the wet bulb temperature.

The influence of acclimatization in enabling men to work at high temperatures is mentioned, and instances relating to mine work are given. While there can be no doubt of the importance of the rôle played by acclimatization, it appears to us that some of the examples given are not very convincing. The first example is taken from Moss[1] who found that acclimatized miners at Pendleton Colliery (Lancashire) carried out effective work at a temperature of 100.5°F. dry bulb and 86.5°F. wet bulb. In the original paper we find Moss claims that "even with so low a wet kata cooling power (4.0), men can load and get coal in excess of the average for the whole pit. This is information of a very practical character, and shows quite clearly the importance of acclimatization to heat and the fallacy of attaching any value to dry kata cooling powers or to anything but extremely low wet kata cooling powers." Immediately preceding this passage there occurs the following statement from the general manager of the colliery: "One factor, of course, is that the coal at the greatest depth we are now working can be got with a minimum of effort, and as it happens the roof is unaccountably good in some of the deepest places. This has an important bearing on the amount of coal they can produce, because they are not troubled with the following dirt which has to be separated from the coal in filling." Evidently the work of these miners consisted almost entirely in filling the coal into tubs, whereas in other parts of the pit the work of hewing was more arduous, and time had to be spent in sorting out dirt. Although the men in these hot places did secure a relatively large output, it by no means follows that their working capacity was unimpaired by exposure to the high temperatures mentioned. The use of output as a measure of the working capacity of miners working in different places may lead to quite erroneous conclusions.

Another example, relating to Indian coal mines, is cited from Penman,[2] who stated that he found men working in one place at a dry bulb temperature of 100°F. and a wet bulb temperature of 99°F., and that the men were said to have worked under these conditions for several months without suffering harm. Reading the discussion on the original paper we find that Dr. Haldane pointed out that the men could not stay continuously in that place, and that the author of the paper had mentioned that the Indian miners like to go in and come out again to a cooler place and rest.

Reference is made to the kata-thermometer and the determination of cooling power, but the value of the dry kata as an anemometer is barely referred to. In a short section relating to the effect of air movement on cooling power, no distinction is made between the dry and the wet cooling powers, but it is evident that the wet kata cooling power is referred to. It is mentioned that Rees found the

[1] Tr. Inst. Min. Eng., 1924–1925, *68*, 379.

[2] Tr. Inst. Min. Eng., 1928–1929, *76*, 340.

cooling power to be proportional to the square root of the air velocity. Rees' work was done on the wet kata cooling power, and his temperature measurements were made with the unventilated wet bulb thermometer. His results are quite different from those obtained by Hill and his colleagues. Hill's equations connecting air velocity with dry and wet kata cooling powers might well have been quoted.

A note on suggested statutory requirements respecting atmospheric conditions in mines is concluded by citing Moss on the "fallacy" of attaching value to dry kata cooling powers or any but extremely low wet kata cooling powers, although in the previous section the results of Orenstein and Ireland's work in the Rand Mines, showing the reduction of efficiency with diminishing dry kata cooling powers, have been quoted.

No mention whatever is made of the effective temperature scale.

In referring to silicosis the authors mention the toxic action of colloidal silica; but they describe the disease as "the formation of scar tissue consequent upon the lung tissue being cut and injured."

In spite of the defects which have been mentioned, this book by Dr. Payman and Professor Statham reaches a high standard, and should achieve a wide circulation among those who are interested in mining.—*T. Bedford.*